Vapor Pressure of Solid HD

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Vapor Pressure Calculation

$$P_{HD} = n_{HD}\, RT/V$$

$$P_{total} = (n_{HD} + n_{carrier})\, RT/V$$

$$P_{HD} = P_{total} \bullet n_{HD}/(n_{HD} + n_{carrier})$$

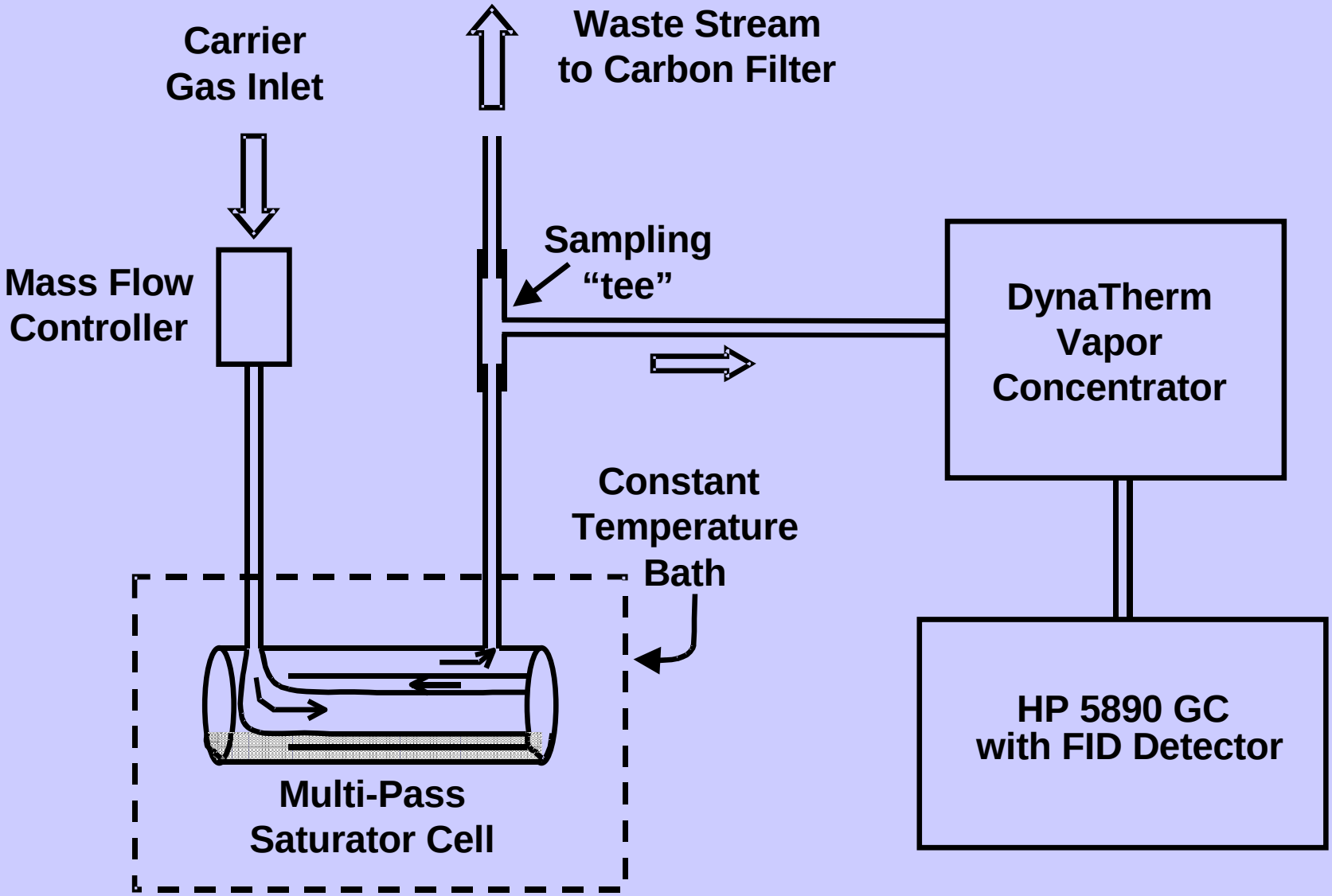
P_{HD} = partial pressure of saturated HD

P_{total} = total system pressure ($P_{HD} + P_{carrier}$)

n_{HD} = moles HD

$n_{carrier}$ = moles carrier gas (dry air)

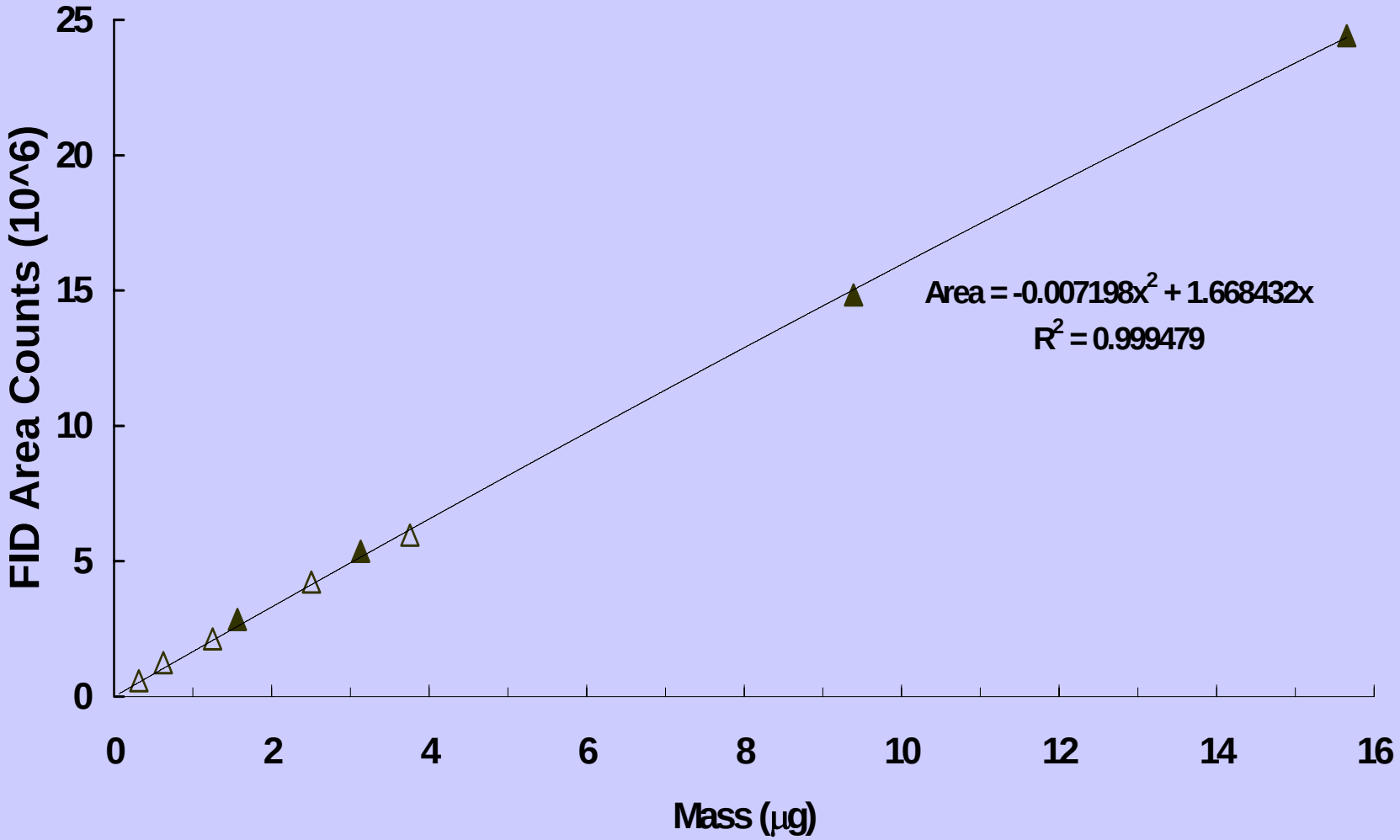
Experimental Set-Up

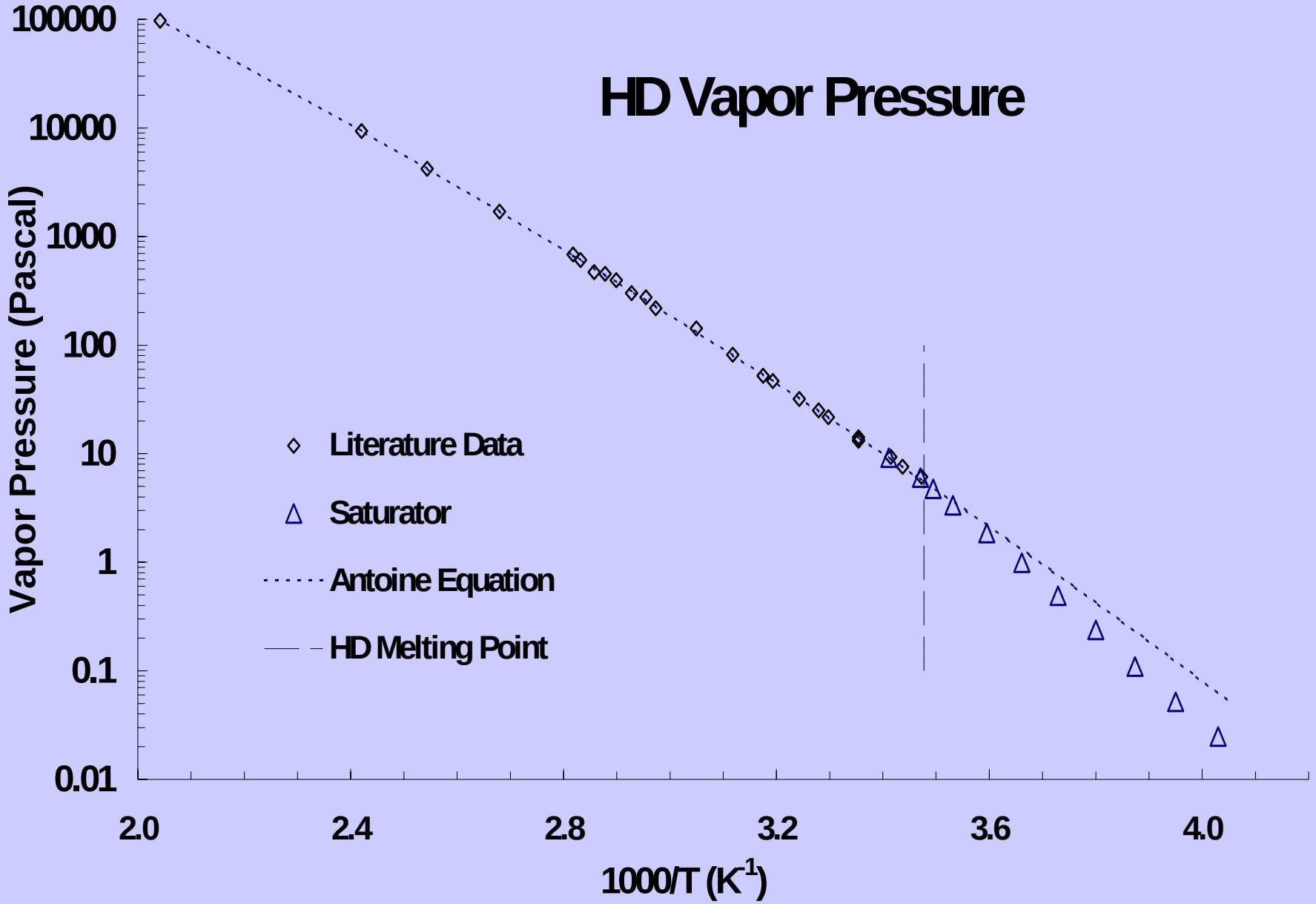


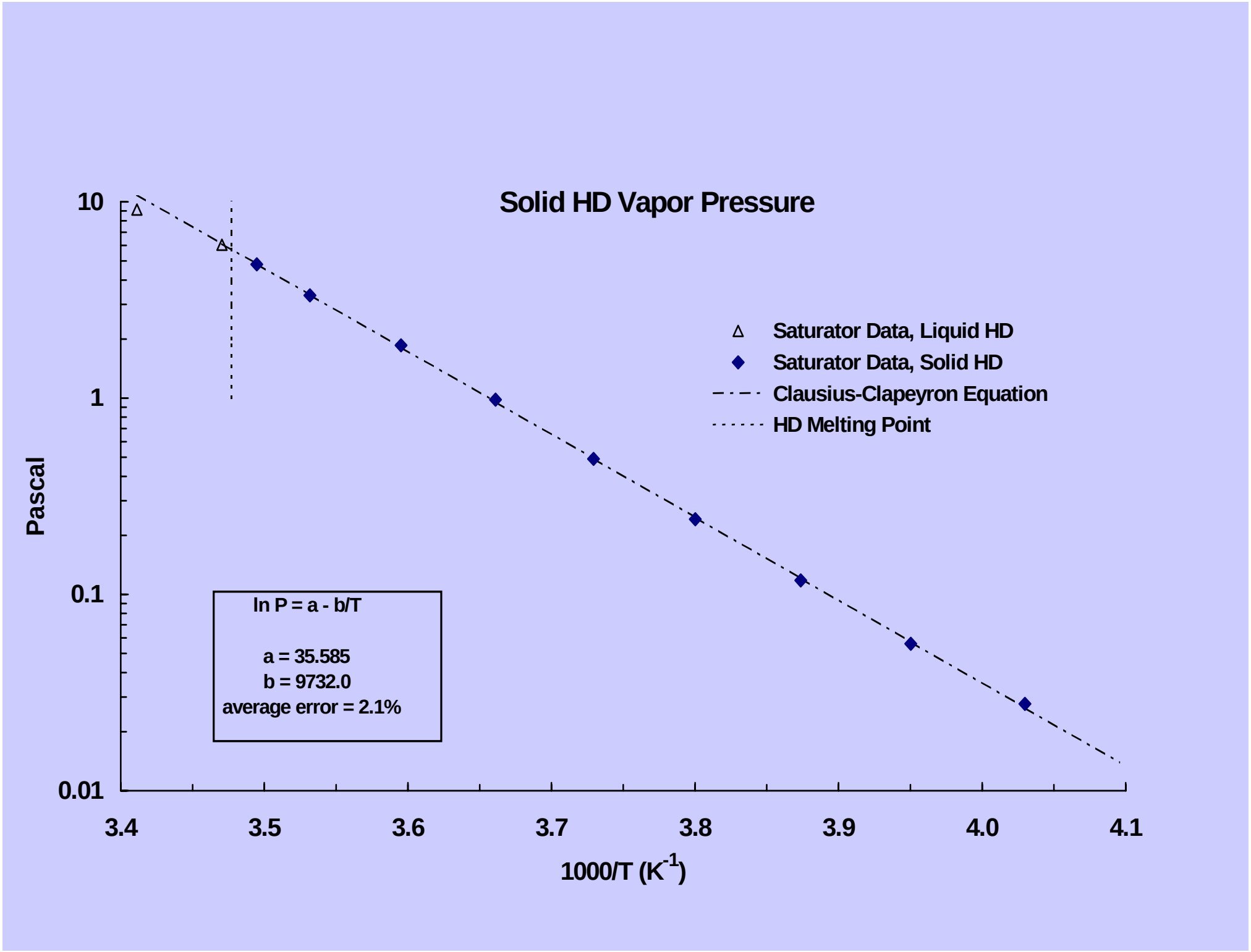
Parameters

Controlled	Measured
Bath Temperature	Ambient Pressure
Saturator Flow Rate	GC Area
Sample Collection Time	GC Response Factor
Sample Flow Rate	

HD CALIBRATION




HD Vapor Pressure
Vapor Pressure (Pascal)
100000
10000
1000
100
10
1
0.1
0.01
2.0
2.4
2.8
3.2
3.6
4.0
1000/T (K-1)
Literature Data
Saturator
Antoine Equation
HD Melting Point


Solid HD Vapor Pressure
Saturator Data, Liquid HD
Saturator Data, Solid HD
Clausius-Clapeyron Equation
HD Melting Point
ln P = a - b/T
a = 35.585
b = 9732.0
average error = 2.1%
Pascal
10
1
0.1
0.01
3.4
3.5
3.6
3.7
3.8
3.9
4.0
4.1
1000/T (K-1)

Measured Data

Temperature (°C)	Vapor Pressure (Pa)		Difference (%)
	Measured	Calculated	
20.0*	9.12	9.16	0.43
15.0*	6.04	5.82	3.48
13.0	**4.81**	**4.83**	**0.47**
10.0	**3.34**	**3.37**	**0.76**
5.0	**1.86**	**1.82**	**2.27**
0.0	**0.984**	**0.957**	**2.70**
-5.0	**0.490**	**0.493**	**0.43**
-10.0	**0.241**	**0.247**	**2.40**
-15.0	**0.118**	**0.121**	**2.56**
-20.0	**0.0560**	**0.0573**	**2.42**
-25.0	**0.0277**	**0.0264**	**4.59**

*** Denotes Liquid HD**

Heat of Vaporization Calculated from Antoine Constants

t (^{o}C)	T (^{o}K)	ΔH_{vap} (kcal/mole)
14.45	287.61	19.34
14.45	287.61	15.30
20	293.16	15.12
25	298.16	14.96
30	303.16	14.82
35	308.16	14.68
40	313.16	14.55
45	318.16	14.42
50	323.16	14.30
55	328.16	14.18
60	333.16	14.07
65	338.16	13.96

Solid HD

Liquid HD

ΔH_{fusion} inferred from this table is 4.0 kcal/mole, in good agreement with the estimate of 4.2 kcal/mole by Buckles (CRLR 542 Special Report, July 1956).

Conclusions

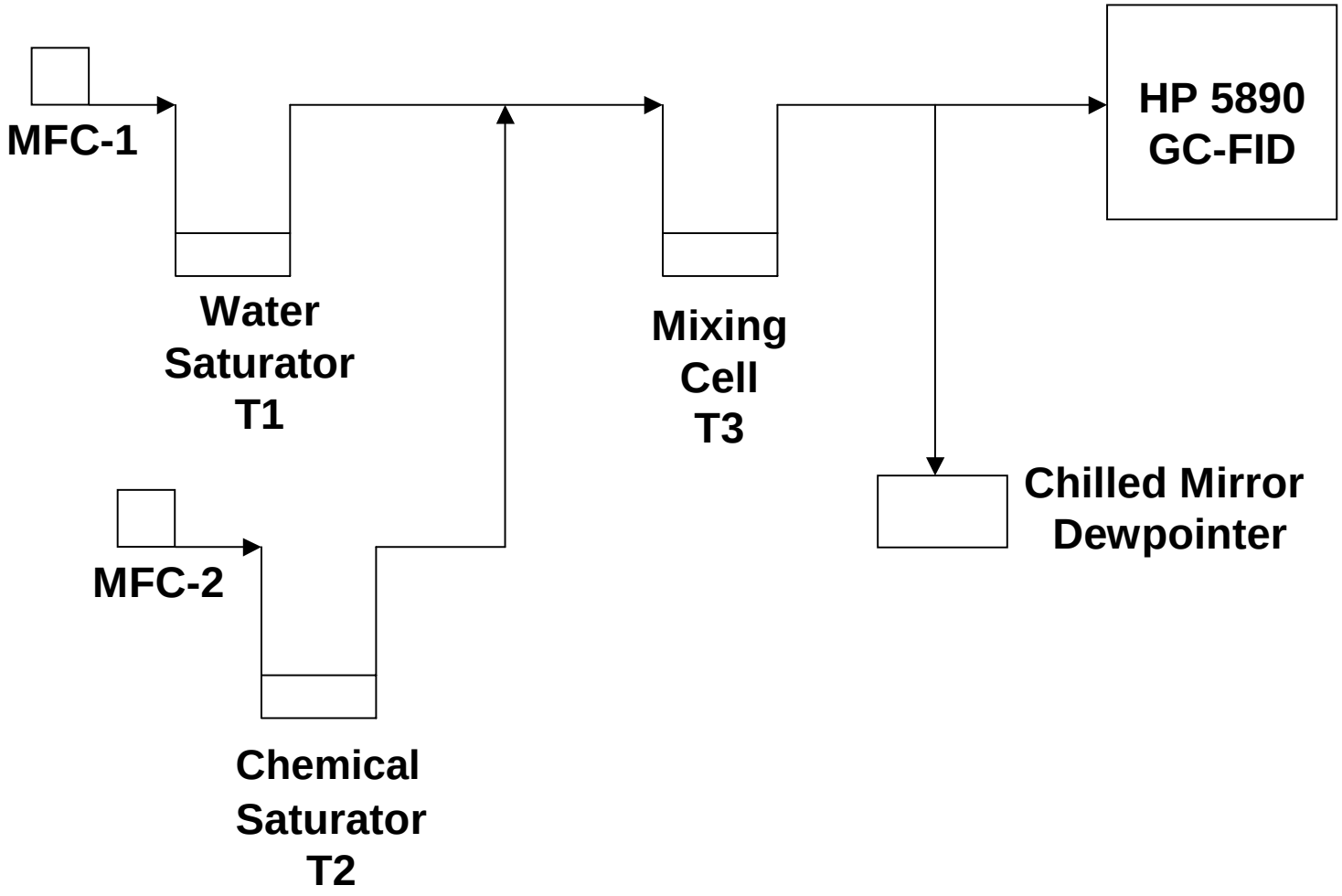
Solid HD vapor pressure measured for first time

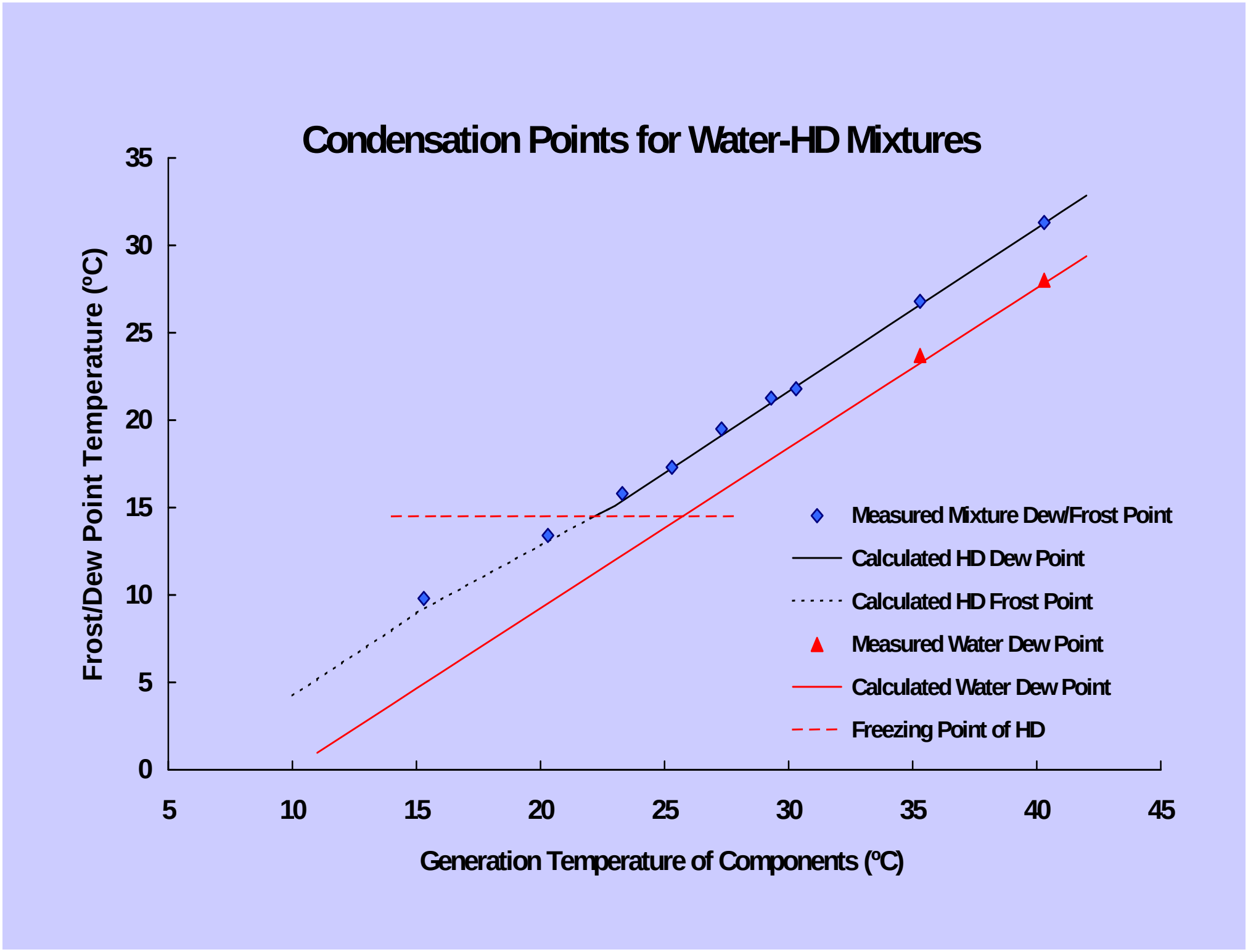
Heat of fusion inferred from liquid and solid Antoine equations is 4.0 kcal/mole, in good agreement with the previous estimate

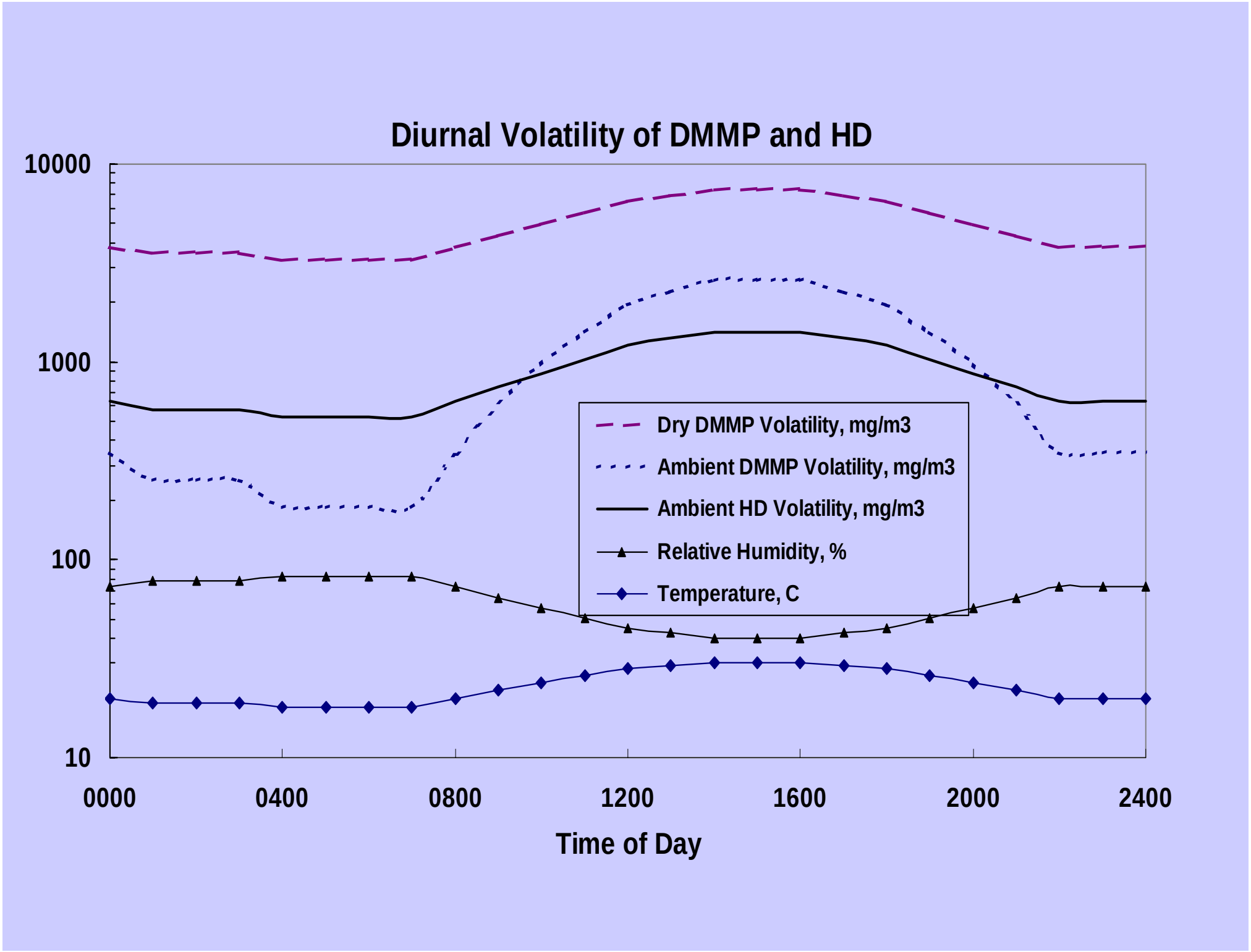
This work was performed as prologue to measurement of the ambient volatility of HD

Ambient Volatility of HD

Experimental Schematic




Condensation Points for Water-HD Mixtures
Frost/Dew Point Temperature (ºC)
Generation Temperature of Components (ºC)
0
5
10
15
20
25
30
35
40
45
Measured Mixture Dew/Frost Point
Calculated HD Dew Point
Calculated HD Frost Point
Measured Water Dew Point
Calculated Water Dew Point
Freezing Point of HD


Diurnal Volatility of DMMP and HD
10000
1000
100
10
0000
0400
0800
1200
1600
2000
2400
Time of Day
Dry DMMP Volatility, mg/m3
Ambient DMMP Volatility, mg/m3
Ambient HD Volatility, mg/m3
Relative Humidity, %
Temperature, C

Preliminary Observations Concerning the Ambient Volatility of HD

In contrast to DMMP, the volatility of HD does not appear to be suppressed by presence of water vapor

DMMP has been shown earlier to be suppressed beyond what would be expected based on Raoult's Law alone by as much as 40%

Projected conditions could result in volatility reversal, i.e., HD volatility may be expected to be higher than DMMP at high-RH conditions

Agent Fate test matrices developed to investigate effect of humidity on HD evaporation rate may be subject to significant simplification since current data suggest minimal effect on HD evaporation rate as a result of high-humidity conditions